PCT/GB2004/002633

The Patent Office

INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

REC'D 30 JUL 2004
WIPO PCT

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

GB04/2633

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated 21 July 2004

Patents Form 1/77

Patents Act 1977
(Rule 16)

The Patent Office

THE PATENT OFFICE
19 JUN 2003
NEWPORT

1/77

19JUN03 E816152-1 C69640
P01/7700 0.00-0314217.1

The Patent Office
0314217.1
Cardiff Road
Newport
South Wales
NP10 8QQ

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

1.	Your reference	IB/jar (PF40)
2.	Patent application number *(The Patent Office will fill in this part)*	0314217.1
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	Polatis Limited 25 Cambridge Science Park Milton Road Cambridge CB4 0FW
	Patents ADP number *(if you know it)*	8105488001
	If the applicant is a corporate body, give the country/state of its incorporation	GB
4.	Title of the invention	FLEXIBLE INCREASE TO OPTICAL SWITCH CAPACITY
5.	Name of your agent *(if you have one)* "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	i.p.21 Limited Norwich Research Park Colney NORWICH NR4 7UT
	Patents ADP number *(if you know it)*	8140410001

		Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
6.	If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number			

		Number of earlier application	Date of filing *(day / month / year)*
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application		

8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	0
Description	4
Claim(s)	
Abstract	
Drawing(s)	

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature ip21 limited by IB Date 18/06/03

12. Name and daytime telephone number of person to contact in the United Kingdom IAN BISHOP 01603 457008

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) *If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.*

b) *Write your answers in capital letters using black ink or you may type them.*

c) *If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.*

d) *If you have answered 'Yes' Patents Form 7/77 will need to be filed.*

e) *Once you have filled in the form you must remember to sign and date it.*

f) *For details of the fee and ways to pay please contact the Patent Office.*

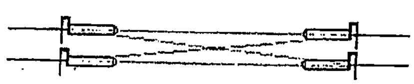
DUPLICATE

Flexible increase to optical switch capacity Andrew Dames, Polatis, 14 June 2003

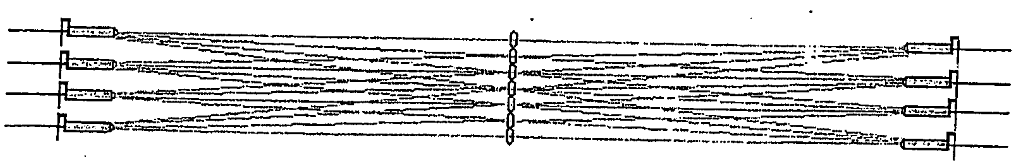
3D optical switches typically built with two arrays of beam steering switches facing each other, each element able to point to each other element. The number of ports that can be addressed is limited by the angular swing of the beams and the working distance/allowable loss of the beams; in addition the resolution of the drive/sensing system can give limitations in the optical stability or noise for large switches, which need fine angular control. To make bigger switches this requires collimators (or other beam forming device) with longer working distance, typically demanding a larger optical aperture, resulting in a bigger device. This is undesirable in itself, but also a major barrier to extending the port count of an existing design, as increasing the optical aperture will generally force a complete reengineering of a product, with large time and cost penalties.

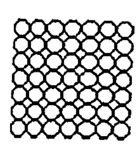
The method disclosed here teaches a way of increasing the capacity applicable to any free space switch based on a regular array of input and or output ports. It is based on the observation that if all interconnection lines are drawn between two arrays (either a linear or 2d) at most points along the axis between the arrays there is a distribution of beams scattered over the area of the array, but at certain places, especially at the center, there are only a limited number of points that the beams pass through. This feature enables an array of optical elements to be placed at those points they pass through. These can be used to reform the beams, giving longer working length from the same collimators. (The maximum gain in working distance is set by the beam diameter approaching the pitch of the array. This limit typically allows paths up to four times longer than in the original switch, giving a 16 fold increase in port count for a 2 D array). The elements can be refractive or reflective depending on the configuration desired.

Alternatively / additionally by placing elements where the beams do not pass through to interleave the image of a different array(s) which can then form a single fully connected switch. This approach relies on the beam diameter being significantly less than the beam crossing pitch. Discussed later under array interleaving.



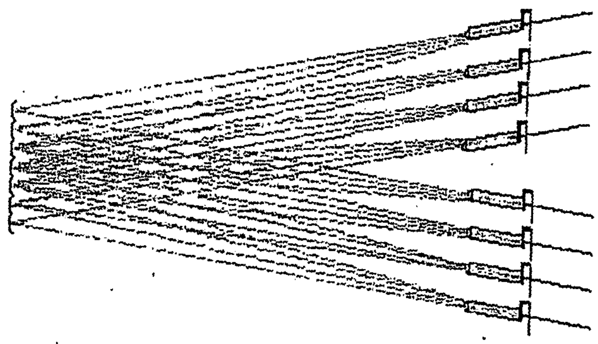
small 4x 4 switch converetd into 16 x 16 switch by adding 7x7 element lens array in center.



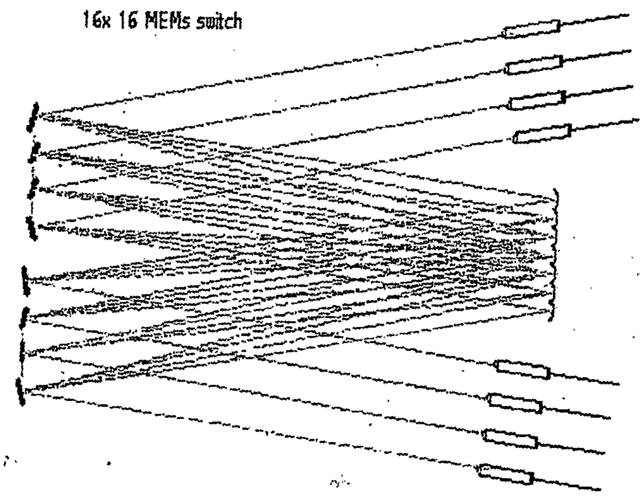


The pitch of the array at the center is exactly half the pitch of the optical pivot points, (these lie at the mirrors in a typical MEMS switch, or at the flexures to deck in a waggly collimator switch). For a 2D array, the horizontal pitch is half the horizontal optical pivot pitch, the vertical pitch half the vertical optical pivot pitch.

Skewed reflective system



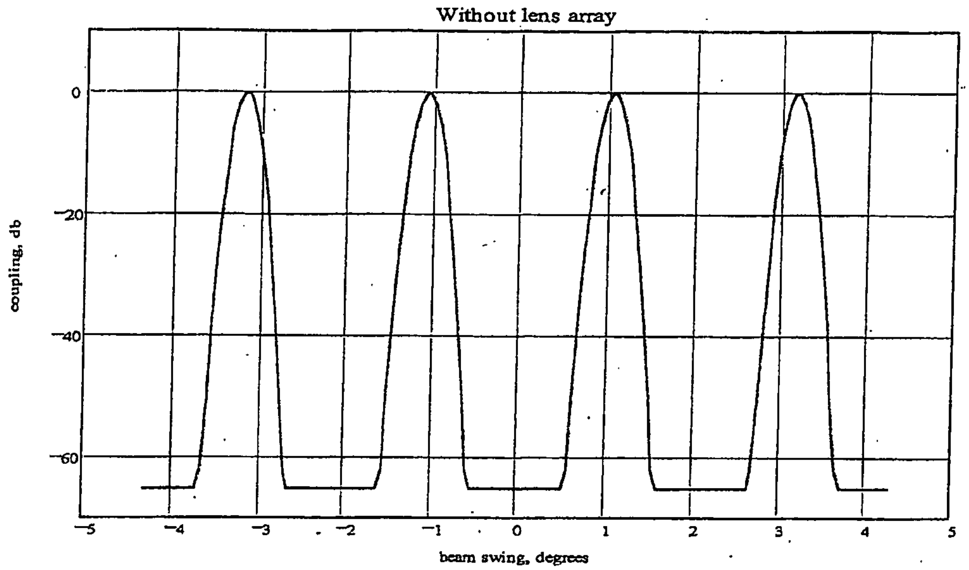
Note that all the pivot points of both input and output arrays all line up in a straight line, (simplifying design and construction), and retain the feature that the array pitch is half the pivot pitch. If tilting mirrors are used fed by separate collimators the collimator arrays are ideally placed in the same plane as the lens array



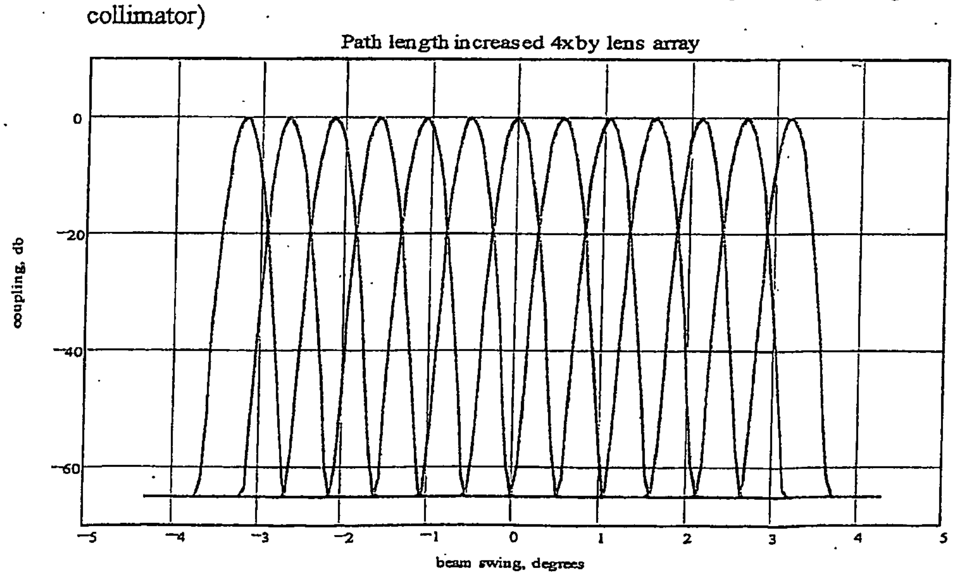
As well as the opportunity to extend existing switch structures to larger port counts, this approach allows a smaller device with lower specification electronics to be built for a given port count.

Fundamentally this approach allows any switch structure to appear to have its collimator spacing set by the maximum desired crosstalk, independent of other engineering considerations which end up with having to have them further apart. In a singlemode system, simply set the radius of curvature of the concave mirror lenslet to match that of the gaussian beam arriving at the lenslet. If a refractive array is used in transmission, the focal length of the lenslets are the same as that of the concave mirrors – 2/radius of curvature of the gaussian beam. The following pictures illustrate a 4 wide array being extended to a 13 wide array using this technique.

Coupling in db for single axis misalignment, single mode gaussian beams, Zo = 50mm, 1550 nm, into 4 wide array, pivot pitch 4.5mm, pivot separation 120mm, optical path 100mm



As above, but 13 wide array, same pitch, pivot separation 480mm, optical path 460mm, 100mm focal length 2.25 mm pitch lenslet array in center of optical path. Note on axis performance vs angle identical, crosstalk 60 db. (Actual devices achieve better than 50 db crosstalk from single end misalignment, approaching 100db with both ends misaligned- ie pointing at adjacent collimator)



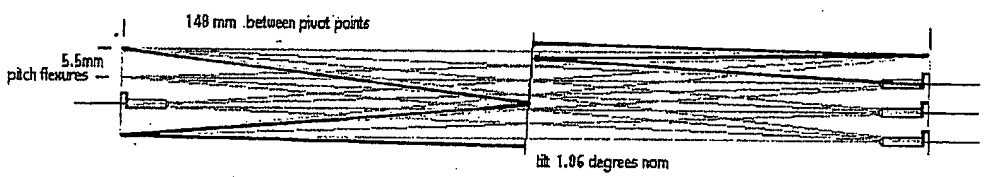
This approach works with both single mode and multimode systems. In multimode systems it has the added benefit of permitting 1 : 1 imaging of the fiber cores, rather than exchanging position

and na between the fibers as in a standard pair of collimators. This gives the advantage of flexibility of working distance (via changing the focal length of the array) without having to change the collimating lenses.

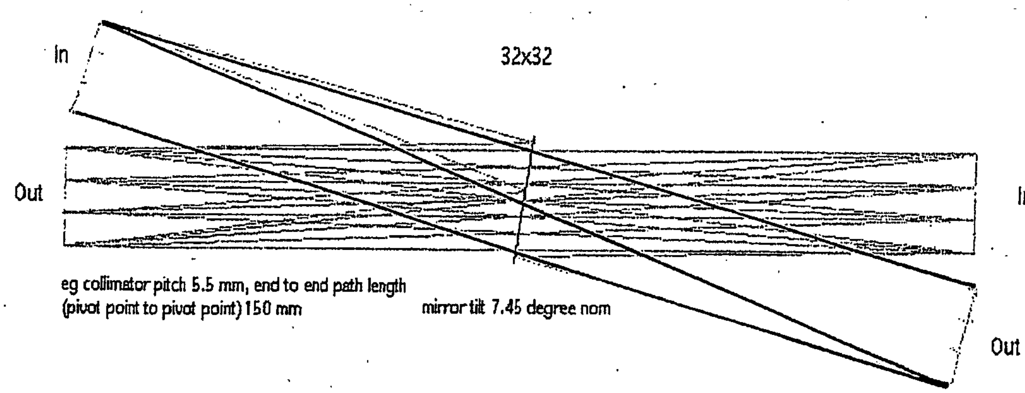
Array interleaving

Relies on gaps between beams to place optical element. Simplest device is stripped mirror, stripes running between the crossing points. Mirror tilted at small angle so that image of collimators in the originating array formed in gaps between collimators of target array. By this means a 16 x 16 switch is converted to a 32 way any to any switch. The stripes on the mirror are at a pitch of half the optical pivot point pitch; hence the reflector width and gap width are both ¼ of the pivot point pitch.

32 Way Reflexive



Alternatively the mirror can be tilted further, and two extra arrays used, to give eg a 32x32 switch from four 16 way arrays.



A technique which gives greater tolerancing in the optical element positioning (or capability of handling larger beam diameters is to use a diagonal checker board array of reflective & transmissive elements. This gives a reflective or transmissive patch size of 1 over two times root two (1/2.81) of the pivot pitch, and requires the element to be mounted at a small angle in both axes to image the collimator arrays properly.
These approaches do not change the apparent distance between the arrays, but interleave their images. Described with reference to waggly collimator switch, but will equally well work with MEMS mirror arrays.

PCT/GB2004/002633